REMARKS

The Office Action says that claim 28 is withdrawn from consideration because it is drawn to nonelected specie II. Claims 1-3 and 22-27 remain under examination in this RCE application. No pending claims have been amended; no claims have been cancelled; and no new claims have been added.

Claims 1-3 and 22-27 were all rejected under 35 U.S.C. 103(a) as being unpatentable over Wang et al. U.S. Patent 6,028,015. The Office Action states that Wang et al. discloses a process for forming an integrated circuit structure having at least one layer of low k material therein and a layer, formed from a low k dielectric layer, suitable for use as an etch stop and/or an etch mask.

The Wang et al. patent teaches a process for treating ***already damaged*** low k insulation material with a hydrogen plasma to react with the broken bond. When forming, for example, vias in such low k dielectric material, the low k insulation material is first masked with a photoresist mask and then etched through the resist mask to form openings in the low k material. The structure is then subject to an oxidation or ashing process which removes the resist mask, but also attacks and severs some of the organic-silicon bonds, oxidizing the organic portion of the bond, and leaving silicon atoms capable of reacting with hydroxyl atoms to form undesirable moisture-containing low k insulation material. The Wang et al. treatment remedies this by providing energized hydrogen atoms to react with such reactive bonds on the damaged silicon atoms ***after*** the steps of forming a resist mask on the layer of low k insulation material, ***after*** etching openings in the low k material through the mask, and then ***after*** removing the mask.

In contrast, Applicants' process is directed to the densification or alteration of the surface of a low k insulation material with a plasma ***before*** formation of a resist mask over the low k layer, ***before*** etching of openings in the low k layer though the resist mask, and ***before*** removal of the resist mask by an oxidation or ashing process. Applicants' purpose in treating such low

k material to densify it is to form a different material on the surface of the low k material to thereby provide a material with different responses to etchant materials than the underlying untreated low k material, thus rendering the densified material suitable for use as an etch stop layer or even as a mask itself. Applicants' claimed invention is, therefore, neither anticipated nor suggested by the teachings of Wang et al.

The Rejection states that the Wang et al. process comprises: forming a first layer of low k dielectric material (10) over a previously formed integrated circuit structure (2), and treating the upper surface of said first layer of low k dielectric material with a plasma to form a first layer of densified dielectric material (14) over the remainder of the underlying first layer of low k dielectric material, citing fig. 4; col. 2, lines 43-56; and col. 3 lines 43-49; whereby said first layer of densified dielectric material (18) is capable of serving as an etch stop and/or an etch mask (fig. 3, ref. 18) for etching of said underlying first layer of low k dielectric material.

Figure 4 of the Wang et al. drawings shows just the opposite of what the Rejection states. Figure 4 clearly recites subjecting the low k sidewall material to a treatment that damages (in the middle box) the low dielectric constant material, and then (subsequently) treating the damages surfaces to repair the damage. In contrast, Applicants' process treats the low k dielectric material to densify it prior to exposing the low k dielectric material to a treatment capable of damaging untreated material. Similarly the passages referred to in column 2, lines 43-56 and column 3, lines 43-49 both teach repairing damaged surfaces of low k dielectric material. The two cited passages in Wang et al. read as follows:

> "The invention comprises a process for treating damaged surfaces of a low dielectric constant organo silicon oxide insulation layer of an integrated circuit structure to inhibit absorption of moisture. The process comprises treating such damaged surfaces of a low dielectric constant organo silicon oxide insulation layer, such as a methyl silicon oxide insulation layer, with a hydrogen plasma. The treatment with hydrogen plasma causes hydrogen to bond to those silicon atoms having dangling bonds which are left in the damaged surface of the low dielectric constant methyl silicon oxide insulation layer to replace methyl groups severed from such silicon atoms at the damaged surface. Absorption of moisture in the damaged surface of the low dielectric constant methyl silicon oxide insulation layer, by bonding of such silicon with moisture, is thereby inhibited." (column 2, lines 43-56 of Wang et al.)

> "Referring now to Figure 3, it will be noted that the damaged portions 16 of the exposed surface sidewalls 14 of opening 12 in layer 10 have been replaced by treated portions 18. In accordance with the invention, damaged portions 16 of low dielectric constant methyl silicon oxide insulation layer 10 are treated with a hydrogen plasma to cause hydrogen from the plasma to bond to the silicon atoms with dangling bonds." (column 3, lines 43-49 of Wang et al. with emphasis added)

The Office Action then states that Wang et al. does not teach forming a first low k material and treating the upper surface of said first low k prior to any exposure of said first low k to etchant, but that selection of any order of performing process steps is prima facie obvious in the absence of new or unexpected results, citing In re Burhans, 154 F.2d 690, 69 USPQ 330 (CCPA 1946). The USPTO then concludes that it would be obvious to one skilled in the art at the time of invention to modify the process of Wang et al. by densifying the first low k prior to etching because densification reduces moisture.

Applicants disagree. Densification is taught by Applicants, not by Wang et al. One cannot change the order of **unknown** process steps. Furthermore, the courts have required some suggestion in a reference of the desirability of a modification. One cannot suggest the desirability of making unknown modifications, or of changing the order of unknown modifications. It is not, from the teachings of Wang et al., obvious to treat the surface of low k material with a densification step ***prior*** to an etching step.

Furthermore, and perhaps most important of all, is the Declaration executed by Wilbur G. Catabay, which accompanied Applicants' Preliminary Amendment dated 04/24/03. As one of the joint inventors of the Wang et al. reference as well as a joint inventor of the pending application.

As one of the joint inventors of the Wang et al. reference as well as a joint inventor of this application, Wilbur G. Catabay is in a unique position to discuss the differences between these two inventions. In his declaration, Catabay points out that hydrogen present in the reducing plasma in the Wang et al. reference, chemically reacts with ***the already broken bonds*** in the low k dielectric material, resulting in the formation of a surface on the low k dielectric layer which, although thin, can ***interfere with the passage of further hydrogen into the low k dielectric layer***.

The Catabay declaration then points out that the densified layer which results from the practice of the instant invention has a thickness ranging from about 300 Å to about 1000 Å, with a typical thickness of about 500 Å. He then estimates the thickness of the layer formed in the Wang et al. reference, as a result of the chemical reaction between the hydrogen in the plasma and the broken bonds in the low k dielectric layer, to be much less, i.e., less than about 100 Å. It should be noted here that such a thin surface coating may be a requirement in the Wang et al. reference since the damages or broken bonds in Wang et al. are located in the exposed sidewall surfaces of vias which are very small in diameter. Formation of a thicker layer in the Wang et al. vias could interfere with subsequent filling of those vias with metal.

Applicants' attorney has stated that the purpose of the Wang et al. process is to address and remedy (not create) the problem of moisture which results from the breaking of bonds in the low k layer during removal of the resist mask ***after*** etching of the via openings. The Wang et al. inventors did not create this problem as alleged in the Advisory Action. Rather, they fixed the prior art problem by reacting hydrogen with the broken bonds in the layer of low k dielectric

material before such broken bonds in the exposed low k sidewalls of the vias have an opportunity to react with moisture.

The purpose of the Wang et al. process is to address and remedy the problem of moisture which results from the breaking of bonds in the low k layer during removal of the resist mask ***after*** etching of the via openings. The Wang et al. inventors did not create this problem. Rather, they fixed the prior art problem by reacting hydrogen with the broken bonds in the layer of low k dielectric material before such broken bonds in the exposed low k sidewalls of the vias have an opportunity to react with moisture.

In contrast, Applicants' process eliminates or at least mitigates the problem of broken bonds in the low k dielectric material by treating the surfaces of the low k dielectric material before exposing such low k surfaces to an oxidizing atmosphere in which such bonds may be broken. The point is not whether Applicants' proposed process is better than the Wang et al. process, but rather that they are not the same nor obvious variants.

The Rejection states that with regard to claim 2, Wang et al. teaches forming a first photoresist mask (40) with a first pattern of openings (fig. 1) therein over said first layer of densified dielectric material (ref. 14) and patterning said first layer of densified dielectric material through said first openings in said first photoresist mask to form a first etch mask layer of densified dielectric material having a pattern of opening in said first etch mask layer of densified dielectric material suitable for use in etching a corresponding pattern of openings in said underlying first layer of low-k dielectric material, citing col.5, line 60 - col. 6, line 16 as support. The cited Wang et al. passage, after acknowledging that the process has only been described with respect to formation of vias, describes further use of their process as follows:

> "For example, if a protective capping layer, such as illustrated capping layer 30,is not formed over the low dielectric constant methyl silicon oxide dielectric constant insulation layer (between the low dielectric constant methyl silicon oxide insulation layer and the resist mask), then this upper surface of the low k dielectric constant methyl silicon oxide insulating layer would also be damaged during the removal of the resist mask, and would need to be ***treated*** by the process of the invention ***after removal of the resist mask***. The treatment of the invention would also have application where a layer of metal interconnects is formed from a metal such as copper which does not pattern well, and the insulation layer is first deposited and patterned prior to deposition of the metal into the patterned trenches (the so-called damacene process). If the insulation layer comprises a low dielectric methyl silicon oxide then the process of the invention should be used to ***treat*** the damaged surfaces of the low dielectric constant methyl silicon oxide insulation layer ***after*** formation of the pattern of trenches therein and removal of the resist mask, and prior to the metal deposition step or steps." (emphasis added)

Note that while the Rejection makes liberal use of the term"densified" in describing the process of Wang et al., the cited text of Wang et al. is silent at this point. To the contrary, It will be noted here that Wang et al., in the passages cited by the USPTO, again reaffirms Applicants' position that in the Wang et al. process, the damage precedes the treatment, unlike Applicants' claimed process.

The Office Action states that, in re claim 22, Wang et al. teaches removing said photoresist mask (40) from said first etch mask layer of densified dielectric material (18) ***before*** etching said first layer of low k dielectric material, citing col. 3, lines 35-40. The cited passage reads as follows:

> "FIG. 2 shows the structure of FIG. 1 after subjecting the structure to an oxidation or ashing process to remove resist mask 40. As seen in FIG. 2, exposed sidewalls 14 of opening 12 in low dielectric constant methyl silicon oxide insulation layer 10 are shown having damaged portions 16 adjacent to the surfaces of sidewalls 14 resulting from contact of these exposed surfaces of opening 12 in layer 10 with the oxidizing or ashing treatment used to remove resist mask 40."

Applicants' reading of this cited passage is that the via openings were formed in the low k dielectric layer before removal of the resist mask, since the text states that the sidewalls of the low k dielectric material were damaged during removal of the resist mask.
Note that Figure 1 shows opening 12 already formed, but undamaged because it is prior to removal of the resist mask 40. In contrast, Figure 2 shows the resist mask gone, and the sidewalls of opening 12 damaged at 16 during the resist mask removal.

The Office Action says that in re claim 3, Wang et al. teaches etching said pattern of opening (12) in said first layer of low k dielectric (10) through said pattern of openings (12) in said first etch mask layer (18) of densified dielectric material thereon. No citation is given in support of such a contention which is at odds with previously referred to passages in Wang et al.

With regard to claim 23, the USPTO states that Wang et al. teaches a process for forming an integrated circuit structure having at least one layer of low k and a layer formed from said low k, suitable for use as an etch mask which consists essentially of:

a) Forming a first layer of low k (10) dielectric material over a previously formed IC structure (2)

b) Treating the upper surface of low k (10) with a plasma formed from a non-oxidizing gas to form a first layer of densified dielectric (14), (fig. 4; col.2, lines 43-56; col. 3, lines 4-49)

c) Forming a photoresist mask (40) over said first layer of densified dielectric (14)

d) Patterning said densified dielectric through said photoresist mask to form a first etch mask layer of densified dielectric material having a pattern of openings (12), (col. 5, line 60 - col. 6, line 16)

e) Removing said photoresist mask before etching any openings through said pattern of openings in said first etch mask layer of densified dielectric material (col. 3, lines 35-40);

Whereby the first layer of the densified dielectric material serves as an etch mask (18) for subsequent etching of said underlying first layer of low k.

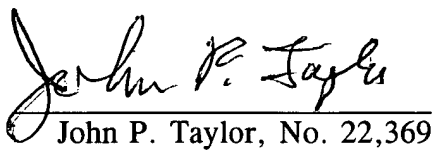
With regard to the cited passages in Wang et al. offered in support for these contentions, Applicants have reviewed the passages cited in support for a teaching of the formation of a densified layer in step b and have found no support in Wang et al. Figure 4.. The treatment in Figure 4 is ***after*** damage has been made to the surface of the low k dielectric material. The same teachings are found in the cited passages in column 2 and 3 of In step d, Wang et al., at the cited passageway in columns 5 and 6, again teaches treatment of the low k dielectric layer after the oxidizing step used to remove the resist mask.

With regard to step e, the passage cited in Wang et al. in support (column 3, lines 35-40, teach just the opposite of what the USPTO contends. The cited passage states that the surfaces of the sidewalls are damaged by the ashing treatment used to remove the resist materials. How could such sidewalls be damaged by the oxidizing materials used to remove resist residues if the openings were not formed until after removal of the resist mask?

Wang et al. does not teach Applicants densification process to provide a protective layer of densified low k dielectric prior to exposure of the low k dielectric material to reagents which could damage the low k dielectric material. Applicants' claims are patentable over the cited art.

If the Examiner in charge of this case feels that there are any remaining unresolved issues in this case, the Examiner is urged to call the undersigned attorney at the below listed telephone number which is in the Pacific Coast Time Zone.

Respectfully Submitted,



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